Module III Product Quality Improvement

Lecture 5 - How six sigma philosophy is aligned with product quality improvement?

In 2000, M. Harry and R. Schroeder published '*Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*'. Since that time, there has been considerable interest in this subject. In this book, the authors devoted much space to a review of the concept. In the Six Sigma world, the Quality Planning Process is referred to as Design for Six Sigma (DFSS). DFSS is focused on creating new or modified product designs that are capable of significantly higher levels of performance (using Six Sigma Methodology). They emphasized on a Define-Measure-Analyze-Design-Verify (DMADV) sequence of quality planning and design methodology that can be used for product or service desing. The DFSS matrix is a tool which captures the important quality planning information that allows a six sigma team to record the vital planning information and deliver as required in the DMADV phases.

Statistical Concept for Six Sigma

According to James Harrington, "Six sigma is simply a TQM process that uses process capability analysis as a way of measuring improvement". Sigma, σ, is the Greek symbol for the statistical measurement of dispersion, so-called standard deviation. It is the best measurement of process variability, as smaller the deviation value, the less variability is there in the process. **Figure 3.20** shows measurement (Y characteristic) on samples collected from that is normally distributed and centered exactly on target, having the upper and lower specification limit (USL and LSL). The estimated $\pm$ 6σ fits exactly with specification limit. For such situation, 99.9999998% of the product or service will be between specifications, and the nonconformance rate will be 0.002 parts per million, or 2.0 parts per billion. The situation diagrammed represents a process capability index (C_p & C_{pk}) of 2.0. A C_{pk} of 1.33 has been considered in industry as a de-facto standard earlier. **Table 3-7** shows the percent between specifications, the nonconformance rate, and process capability for different specification limit locations.

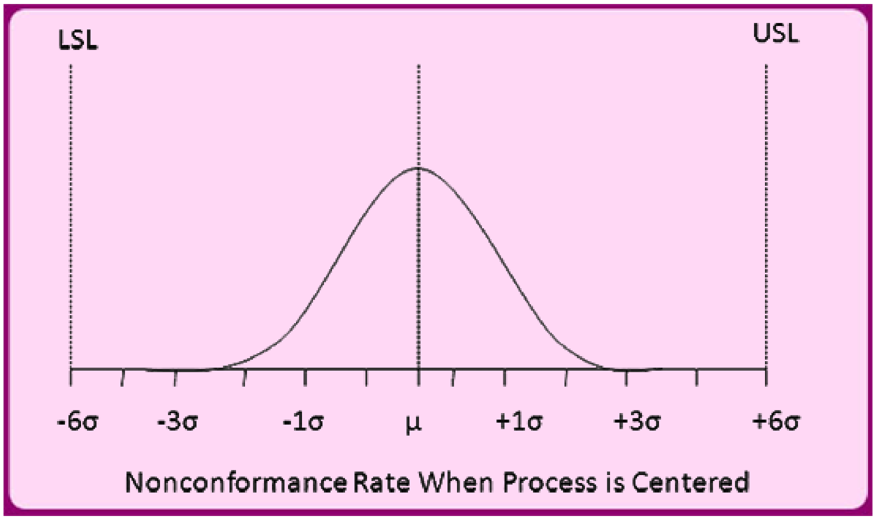

Figure 3-20 Normal Distribution and Specification bound for a Quality Characteristics

Table: 3-7 Process centered on Target

Specification limit	Percent conformance	Nonconformance rate(ppm)	Process capability (C_{pk})
±1σ	68.70	317300	0.33
±2σ	95.45	485500	0.67
±3σ	99.73	2700	1
±4σ	99.9937	63	1.33
±5σ	99.999943	0.57	1.67
±6σ	99.9999998	0.002	2

According to the six-sigma philosophy, any process rarely stay centered-the center tends to "shift" above and below the target, μ. **Figure 3-21** shows a process that is normally distributed, but has shifted within a range of 1.5σ above and 1.5σ below the target. For the **Figure 3-21** situation, 99.9996600% of the product output or service output characteristic will be between specifications and the nonconformance rate will be 3.4 ppm. The off-center situation gives a process capability index (C_{pk}) of 1.5 with 1.33 being the defacto standard previously. **Table 3-8** shows the percent between specifications, the nonconformance rate, and capability for different specification limit locations for an off-centered process. The magnitude and type of shift is a matter of analysis and should not be assumed ahead of time. There is rare evidence of case studies in literature that indicates a shift more than 1.50 σ. The automotive industry recognized the concept of Six Sigma in the mid-1980's, evaluated it and deemed it acceptable. It is to be noted that the original work on six sigma was based on a few empirical studies of a single output.

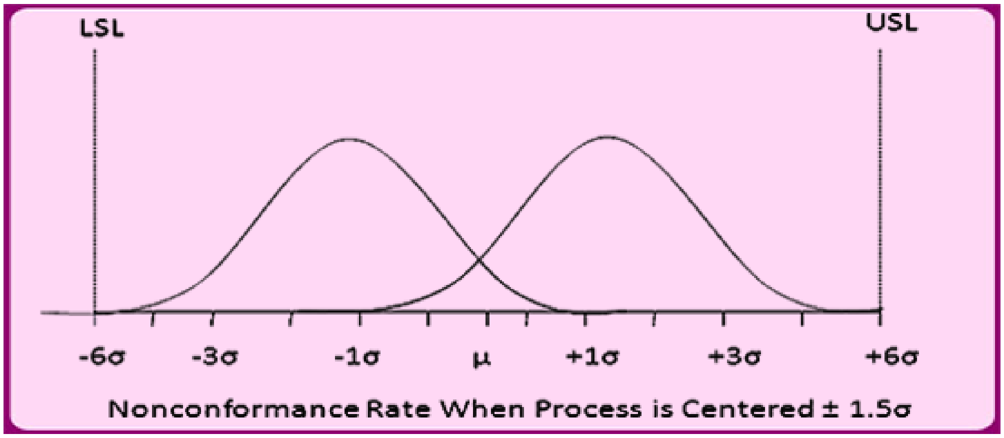

Figure 3-21 Shift in process output characteristic mean

Table: 3-8 Process off-centered by 1.5 σ

Specification limit	Percent conformance	Nonconformance rate(ppm)	Process capability (C_{pk})
±1σ	30.23	697700	-0.167
±2σ	69.13	308700	0.167
±3σ	93.32	66810	0.5
±4σ	99.379	6210	0.834
±5σ	99.9767	2330	1.167
±6σ	99.9966	3.4	1.5

The statistical aspects of six-sigma tell us that we should reduce the process variability, σ, and try to keep the process centered on the target, μ. These concepts are not new, and had been long advocated by Shewhart, E Deming, and G Taguchi.

Six Sigma DMAIC Methodology

The standard problem-solving approach used in Six Sigma is known as DMAIC(Define, Measure, Analyze, Improve, and Control).

Define Phase

After a Six Sigma project is selected, the first step is to clearly define the problem. This activity is significantly different from project selection. Project selection generally responds to symptoms of a problem and usually results in a rather abstract problem statement. One must describe the problem in operational or measurable terms that facilitate further analysis. For example, a firm might have a history of poor reliability of electric generator it manufactures, resulting in a Six Sigma project to improve generator reliability. A preliminary investigation of warranty and field service repair data might suggest that the source of most problems are brush wear, and more specifically, suggest a problem with brush hardness variability. Thus, the problem might be defined as "reduce the variability of brush hardness." This process of drilling down to a more specific problem statement is sometimes called project scoping.

A good problem statement also should identify the customer (external or internal) and the CTQ (Critical-to-Quality) Characteristics that have the most impact on product or service performance, describe the current level of performance or the nature of errors or customer complaints, identify the relevant performance metrics, benchmark best performance standards, calculate the cost/ revenue implications of the project, and quantify the expected level of performance from a successful Six Sigma effort. The Define phase should also address such project management issues as what will need to be done, by whom, and when.

Measure

This phase of the DMAIC process focuses on how to measure the internal processes that impact CTQ’s. It requires an understanding of the causal relationship(s) between process performance and customer concept of value. However, once they are understood, procedures for gathering facts-collecting reliable data or observations, and careful listening-must be defined and implemented. Data from existing production processes and practices often provide important information, as does feedback from supervisors, workers, customers, and field service employees. An important concept required at this stage is 'Opportunity' and 'Rolled Throughput Yeild' (http://asq.org/qic/display-item/?item=15398).

Analyze

A major flaw in many problem-solving approaches is a lack of emphasis on rigorous statistical analysis. Too often, we want to jump to a solution without fully understanding the nature of the problem and identifying the source of the problem. The Analyze phase of DMAIC focuses on why defects, errors, or excessive variation occur.

After potential causal variables are identified, statistical experiments are conducted to verify them. These experiments generally consist of formulating some hypothesis to investigate, collecting data, analyzing the data, and reaching a reasonable and statistically supportable conclusion. Statistical thinking and analysis plays a critical role in this phase. It is one of the reasons why statistics plays an important part in Six Sigma training.

Improve

Once the root cause of a problem is understood, the analyst or team needs to generate ideas for removing or resolving the problem and improve the performance measures or CTQ. This idea-gathering phase is a highly creative activity, because many optimal solutions are not obvious. One of the difficulties in this task is the natural instinct to prejudge ideas before thoroughly evaluating them. Most people have a natural fear of proposing a "silly" idea or looking foolish. However, such ideas may actually form the basis for a creative and useful solution. Effective problem solver must learn to defer judgment and develop the ability to generate a large number of ideas at this stage of the process, whether practical or not.

After a set of ideas have been proposed, it is necessary to evaluate them and select the most promising. This process includes confirming that the proposed solution will positively impact the key process output variables or CTQ, and identifying the maximum acceptable ranges of these variables.

Problem solutions often entail technical or organizational changes. Often some sort of decision model is used to assess possible solutions against important criteria such as cost, time, quality improvement potential, resources required, effects on supervisors and workers, and barriers to implementation such as resistance to change or organizational culture. To implement a solution effectively, responsibility must be assigned to a person or a group who will follow through on what must be done, where it will be done, when it will be done, and how it will be done.

Control

The Control phase focuses on how to maintain the improvements, which includes putting statistical process control (SPC) in place to ensure that the key variables remain within the naturally acceptable limits under the modified process. These improvements might include establishing the new standards and procedures, training the workforce, and instituting controls to make sure that improvements do not die over time. Controls might be as simple as using checklists or periodic status reviews to ensure that proper procedures are followed.

Overall, Six Sigma Methodology is to work smarter not harder. It also emphasizes on measurement(s) that impact customer, ways to improve the process, and decision making based on firm statistical concept. Reader may refer any standard book/references given below to learn further on Six Sigma Methodology.